ISOTROPIC RADIATOR

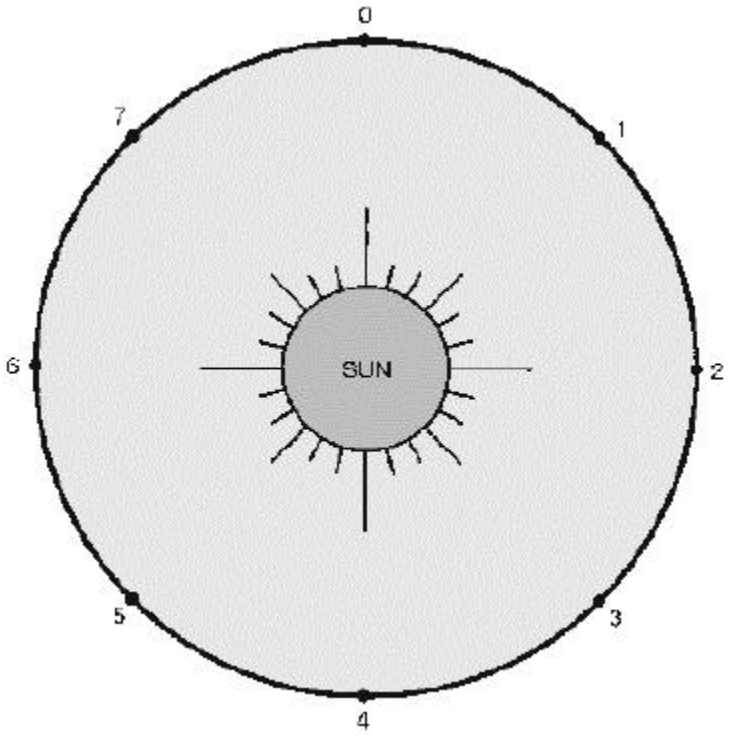

Figure-1: The Sun is considered an isotropic radiator. Some antenna sources radiate energy equally in all directions. The energy radiated measured at any fixed distance and from any angle will be approximately the same.

*An **isotropic radiator** is a **'theoretical'** point source of waves, which exhibits the same magnitude or properties when measured in all directions. It has no preferred direction of radiation.* It radiates uniformly in all directions over a sphere centered on the source. **It is a reference radiator with which other sources are compared.** Isotropic radiators obey Lambert's law.

Antenna Theory

In antenna theory, the isotropic radiator is a theoretical radiator having a directivity of '0 dBi" (dB relative to isotropic), which means that the radiator equally transmits (or receives) electromagnetic radiation from any arbitrary direction. In reality, a **coherent** isotropic radiator cannot exist, as the isotropic radiator, with a radiation pattern (as expressed in spherical coordinates) of

$$E\left(r,\theta,\phi\right)=\frac{e^{jkr}}{4\pi r}$$

(note that this function is independent of the spherical angles θ and would violate the Helmholtz Wave Equation, as derived from Maxwell's Equations.)

Although the Sun and other stars radiate equally in all directions, their radiation pattern does not violate Maxwell's equations, because radiation from a star is **incoherent**.

Even though an isotropic radiator cannot exist in practice, antenna directivity is usually compared to the directivity of an isotropic radiator, **because the gain (which is closely related to directivity)** relative to an isotropic radiator is useful in the Friis transmission equation. **The smallest directivity a radiator can have relative to an isotropic radiator, is a Hertzian Dipole, which has +2.14 dBi.**

If “P” watts are supplied to an isotropic radiator, the energy density (watts per square meter) at a distance “R” meters from the center of the radiator is P/(4 pi R^2). This is because power “P” spreads uniformly across the area (4 pi R^2) of a sphere of radius “R”.

An antenna emits an electromagnetic wave that has two components - the electric (E) and magnetic (H) fields. These are at right angles to each other and also at right angles to the direction of travel of the wave. This presents a problem for a theoretical isotropic radiator since there will be places on the unit sphere where we cannot specify a unique "polarization direction" for the direction of the electric field. Everything else is called anisotropic radiation.

True isotropic radiators do not exist in reality. This is because the electromagnetic wave is made up of two perpendicular components - the electric field E and the magnetic field H. The emitted electromagnetic wave moves perpendicular to the E-plane and H-plane. The wave cannot be lined up so that there is radiation in all directions and that neither the E or H planes cancel each other out. There must be a discontinuity.

This is best described as a topological theorem, the hairy ball theorem - one cannot comb the hair on a ball in a smooth manner so that there is no part or bald spot. In the same way, it is not possible to cover a sphere with square magnets so that they don't repel each other somewhere.

It is possible, theoretically, to build an antenna that transmits power isotropically. Though such an antenna cannot transmit plane polarization in

every direction. Equal power over the sphere can be achieved by transmitting in two orthogonal polarizations. These polarizations must vary across the sphere to accommodate the hairy ball theorem. Though, for most purposes of antenna theory such an antenna is not useful.

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